R E P O R T R E S U M E S

ED 012 239 SE 001 653

A REVIEW OF NEW SCIENCE CURRICULUM MATERIALS.

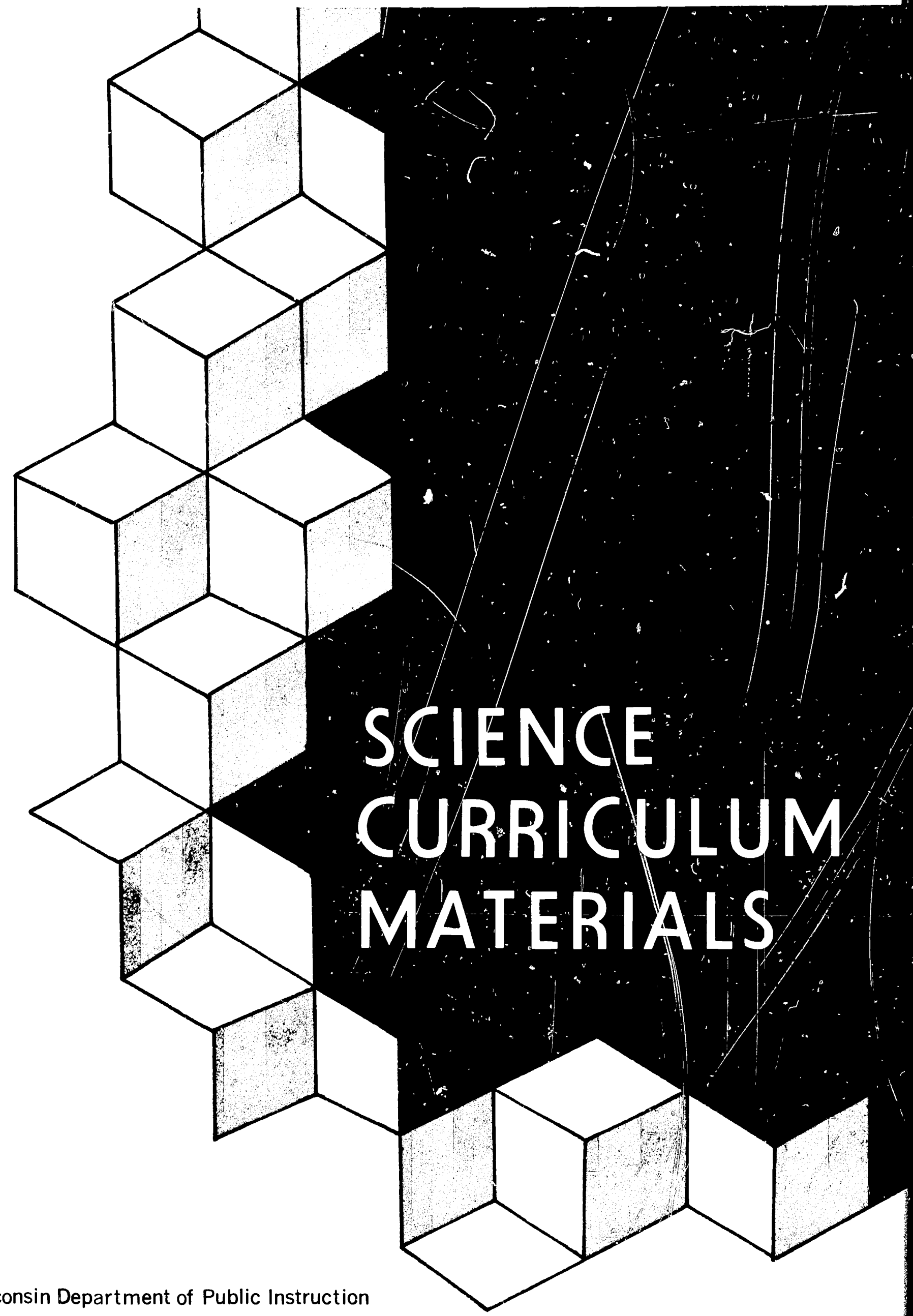
BY- O'HEARN, GEORGE T.
WISCONSIN STATE DEPT. OF PUB. INSTR., MADISON

PUB DATE 66

EDRS PRICE MF-$0.09 HC-$1.56 39P.

DESCRIPTORS- *CURRICULUM DEVELOPMENT, *ELEMENTARY SCHOOL SCIENCE, *SECONDARY SCHOOL SCIENCE, *SCIENCE COURSE IMPROVEMENT PROJECT, *SCIENCE MATERIALS, *SCIENCE EQUIPMENT, ASTRONOMY, BIBLIOGRAPHIES, BIOLOGY, CHEMISTRY, EARTH SCIENCE, PHYSICS, PHYSICAL SCIENCES, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, BIOLOGICAL SCIENCE CURRICULUM STUDY, CHEMICAL BOND APPROACH, MINNEMAST, MADISON

DESCRIBED ARE CURRICULUM MATERIALS PREPARED BY 22 ELEMENTARY AND SECONDARY SCIENCE COURSE IMPROVEMENT STUDY GROUPS. AN INTRODUCTORY SECTION DEALING WITH THE NEW CURRICULUMS DISCUSSES THE FOLLOWING TOPICS--(1) CHANGES IN THE ACTIVITIES AND RESPONSIBILITIES OF TEACHERS AND STUDENTS, (2) COURSE CONTENT AND ORGANIZATION, (3) CURRICULUM MATERIALS DEVELOPMENT, (4) STUDENT ABILITY GROUPING, AND (5) IMPLICATIONS FOR TEACHER PREPARATION. ANOTHER SECTION IS DEVOTED TO INDIVIDUAL PROJECTS. INFORMATION CONCERNING THE PROJECTS INCLUDES (1) THE PROJECT TITLE, (2) THE PROJECT DIRECTOR'S NAME AS WELL AS THE LOCATION OF THE PROJECT CENTER, (3) THE RATIONALE OF THE PROJECT, AND (4) MATERIALS PRODUCED. TYPES OF MATERIALS INCLUDE TEACHER GUIDES, STUDENT TEXTBOOKS, LABORATORY MANUALS, SUPPLEMENTARY READINGS, PROGRAMED INSTRUCTIONAL MATERIALS, TESTS, SPECIAL EQUIPMENT AND KITS, AND FILMS AND OTHER AUDIOVISUAL AIDS. A FINAL SECTION INCLUDES AN EXTENSIVE LIST OF ARTICLES RELATIVE TO THE NEW SCIENCE CURRICULUMS. THIS DOCUMENT IS AVAILABLE FROM THE WISCONSIN STATE DEPARTMENT OF PUBLIC INSTRUCTION, DIVISION OF INSTRUCTIONAL SERVICE, MADISON, WISCONSIN. (AG)



SCIENCE CURRICULUM MATERIALS

Wisconsin Department of Public Instruction
William C. Kahl, State Superintendent

A REVIEW

OF

NEW SCIENCE CURRICULUM MATERIALS

Written by

George T. O'Hearn, Assistant Professor
Department of Curriculum and Instruction
School of Education
The University of Wisconsin

for

NDEA Section
Division of Instructional Services
State Department of Public Instruction
Madison, Wisconsin

William C. Kahl
State Superintendent

3000-19

FOREWORD

For several years science courses and science curriculum materials for kindergarten through high school have been developed at a rate that makes it very difficult for the classroom teacher to stay up-to-date. To know what materials have been published and what new equipment has been developed has alone become a considerable task. It is even more time consuming and difficult to read the materials and to discover how all of the developments can best be implemented in local schools.

However, in spite of the difficulty, it remains the professional responsibility of teachers and school administrators to take advantage of these resources in improving their educational programs. To help with this responsibility in science education, the Wisconsin Department of Public Instruction, with support of Title III of the National Defense Education Act, has attempted to make information about such developments easily available through this publication.

It is intended that those who make use of this booklet treat it as an introduction to further investigation. The listing of materials for individual projects is not exhaustive. The philosophies and learning theories upon which the science teaching programs are based are only briefly described. There has been no attempt at critical evaluation. For these reasons an extensive bibliography is included as well as the addresses of project directors from whom much additional information can be obtained. It is hoped that when a particular project or some of its materials have special pertinence to a local program the reader will make the extra effort necessary to obtain greater information.

William C. Kahl

William C. Kahl
State Superintendent

TABLE OF CONTENTS

		Page
I	Introduction - New Science Curricula	1
	New Curricula and the Student	1
	New Curricula and the Teacher	2
	New Curricula - Their Content and Organization	3
	New Curriculum Materials	3
	Teacher Guides	3
	Student Textbooks	3
	Laboratory Manuals	4
	Special Materials and Kits	4
	Films	4
	Programmed Instruction	5
	Supplementary Reading Materials	5
	Materials for Evaluating and Testing Student Achievement	5
	Guides for Curriculum Development	5
II	Attention to Special Problems	6
	Ability Grouping	6
	Teacher Preparation	6
III	Where to Look for Further Information	7
IV	Listing of Curriculum Studies	11
	1. AAAS Science - A Process Approach	11
	2. BSCS - Biology Course	11
	3. BSCS - Biology-Second Course	12
	4. BSCS - Special Materials Course	13
	5. CBA - Chemistry	13
	6. CHEM - Chemistry	14
	7. ECC - Engineering	14
	8. ESCP - Earth Science	15
	9. ESP - Elementary Science-Howard University	15
	10. ESS - Elementary Science-ESI	15
	11. ESSP - Elementary Science-California	16
	12. ESSP - Elementary Science (Astronomy)-Illinois	16
	13. ESSP - Elementary Science-Utah	17
	14. HPP - Physics	17
	15. IPS - PSSC - ESI	18
	16. Minnemast	18
	17. Portland Project	19
	18. PSSC - ESI - Advanced Physics Course	19
	19. PSSC - ESI - Physics Course	20
	20. SCIS - California	20
	21. SSCP - Illinois	21
	22. SSSP - Princeton Geology Project-Time, Space, Matter	21
V	Bibliography	22
VI	Index	31

LIST OF TABLES

Table Number		Page
I	Curriculum Projects - Primary Grades	8
II	Curriculum Projects - Intermediate Grades	8
III	Curriculum Projects - Junior High School	9
IV	Curriculum Projects - Senior High School	10

I INTRODUCTION - NEW SCIENCE CURRICULA

Science is a human activity; an intellectual activity whose products include facts, theories, concepts, and principles. These products are not unchanging dogma, but change as new facts are discovered, new theories advanced, and old theories modified. Change is as much a part of science as is any of the processes of science.

The new curricula are the result of attempts by scientists, science educators, and teachers to change the science taught in our schools. Consequently, these new curricula stress that science instruction, kindergarten through twelfth grade, should:

1. include the currently accepted theories, concepts, and facts of the various disciplines;

2. include the processes of science, i.e., measurement, observation, classification, which the scientist uses in developing these concepts, theories, and facts;

3. reflect the nature of science as an ever-changing, self-correcting enterprise; and

4. be able to keep in step with scientific developments rather than lag many years behind.

This pamphlet, a review of new science curriculum projects, is written for the classroom teacher. Its purpose is to provide a review of individual projects, briefly examine new trends, and cite classroom aids and sources of information available to the teacher. No effort has been made to provide the history of these projects. This is available in many other publications. No effort has been made to list all the materials produced by the various studies. Only samples of the products (texts, guides, etc.) are listed. New units are being produced every day, and complete current lists may be obtained from the directors of the studies listed in this pamphlet.

New Curricula and the Student

In the new curricula, the student learns the intellectual products of science (concepts, theories, facts) as well as the processes which produce these products. He makes things happen. He handles material, he makes observations, he carries out investigations and interprets results. This is true of all the new curriculum studies. At the primary school level, a study such as AAAS Science - A Process Approach emphasizes the development of competence in skills basic to further learning as related to the sciences. In this study, the student is introduced to a variety of content while learning of such processes as measuring, communicating, predicting, and classifying. Consequently, the student is constantly making discoveries and organizing the processes and content which he is learning into some sort of fabric meaningful to him. Similar emphases on the processes and content of science are found in the other curriculum studies at the elementary school level. See Tables I and II for listings of the curriculum projects relevant to the primary and intermediate school grades.

The emphases on the student as an active participant continue into the junior high school programs where the content of the various disciplines becomes more clearly defined. The Earth Science Curriculum Project, the Illinois Astronomy Project, and the Geology Project (SSSP - Time, Space and Matter) emphasize specific subject matter content from their respective disciplines. But the student's contact with the laboratory and with the processes of science used in developing the subject matter content is also emphasized. See Table III for a listing of junior high school curriculum projects.

At the senior high school level, all of the courses (physics, chemistry, biology, and earth science) emphasize student investigational activities. Many of these activities take place in the laboratory where the student is to develop an understanding of the investigational procedures basic to the discipline being studied. However, not all investigations take place in the laboratory. The classroom, the library, and even the armchair can and do serve as locales for student investigations. In all of these curriculum studies the student becomes the investigator while the teacher, texts,and reference material provide bits and pieces of information, background knowledge, and the direction to lead him on his way. See Table IV for a listing of senior high school curriculum projects.

New Curricula and the Role of the Teacher

The emphases of the new curricula on student activities place a corresponding responsibility on the teacher as a planner and director of learning activities. The teacher is not only a disseminator of knowledge, but a director of learning. He is a knowledgeable planner, leader, and director of activities as well as of content learning. And this requires a thorough acquaintance with the objectives of the curriculum, adequate subject matter background in the science, and a commitment to keep abreast of developments in that science.

Summer institutes and academic-year institutes have been initiated by the various curriculum projects to aid the teacher in developing the required competencies. A list of these institutes may be obtained by writing to Teacher Education Section, National Science Foundation, Washington, D. C. 20550.

Much of the teacher's time is spent in preparing for classroom instruction. The inquiry or investigational approach emphasized by these studies necessitates careful structuring and advance planning by the teacher prior to class. Almost every elementary science curriculum study has produced a teacher's guide which serves not only to give the teacher specific assistance on a day-by-day basis, but also to provide general background information for the teacher. At the junior and senior high levels, additional aids supplement the teacher guides. Technique films, designed to acquaint the teacher with certain laboratory procedures, and guides to the use of laboratory equipment and materials are available.

Selecting curricular materials from those in current production places another responsibility on the teacher. Intelligent selection can be made only with knowledge of what is available. Fortunately, descriptive materials are readily available from the directors of the various projects. And the texts, teachers guides, etc. are available for review or can be purchased at a nominal cost. A comprehensive review of the curriculum projects is available from the Information Clearing House in New Science and Mathematics Curricula, Science Teaching Center, University of Maryland, College Park, Maryland.

The teacher using materials from these curriculum projects takes on new responsibilities in the evaluation and testing of student achievement. Since the new curricula emphasize processes of science as well as products, it follows that any evaluation procedure devised should determine student achievement in both of these areas. Although some testing materials have been produced by the curriculum studies and are discussed elsewhere in this report, the classroom teacher must devise tests to fit the local conditions. Questions of product (i.e., fact, concept, and theory) and process can be and often are constructed at the knowledge or memory level. But questions and procedures which measure the student's ability to interpret, apply, analyze, synthesize, and evaluate are also needed. Two references, Sanders' Classroom Questions (1966) and Bloom's Taxonomy of Educational Objectives (1956), may provide some guidance to the classroom teacher in the design and construction of more effective evaluation instruments.

New Curricula - Their Content and Organization

At the primary and intermediate school levels, the content of the curriculum studies emphasizes the processes of science. This is particularly apparent in such studies as AAAS Science - A Process Approach and the Minnemast materials. Content in these studies is directed to the most effective learning of the processes of science. In both of these studies, an effort is made to produce an integrated series of units spanning all of the years of the elementary school. The organization is dictated by these process-oriented objectives. In contrast to the organization of AAAS, other projects such as Elementary Science Study and the Elementary School Science Projects in Utah and California have produced a series of separate instructional units appropriate to the elementary school level. Typical of the statements describing the content and organization of this latter type of curriculum project is the following from ESS: "The purpose of the project is primarily that of developing more meaningful materials with little emphasis given toward development of a sequential or continuing program with specific structure as to grade level." The purpose is not to develop a national curriculum, but to supply a variety of carefully thought out and tested materials which the curriculum director of the school system may use in developing an elementary science curriculum for the particular needs of his school system.

At the junior high school level, the content shifts from processes and products of science-in-general to processes and products of specific disciplines. Such projects as the Earth Science Curriculum Project and the Secondary School Science Project (Time, Space and Matter) are organized around interdisciplinary content taken from such areas as geology, geography, geophysics, physics, and chemistry. Other studies such as the Elementary School Science Project (Illinois Astronomy Project) concentrate primarily on a single discipline.

At the senior high school level, a more strictly disciplinary orientation is maintained with clearly separate projects developed in biology, chemistry, physics, geology, and engineering. Within each of these projects, special attention is given to content organization so that it reflects the discipline from which it is taken in process as well as content. The role of man in technological developments is the subject of the Engineering Concepts Curriculum. Its text, The Man-Made World, is designed to fill the gap between the idealized laws of nature and the man-made devices, systems, processes, and structures which fill today's world. Still another organizational approach is being developed by Harvard Project Physics which is stressing the cultural and humanistic aspects of physics.

New Curriculum Materials

An extensive series of curriculum materials and teaching aids has been developed at all school levels by the various curriculum projects. Included for students are textbooks, laboratory guides, laboratory problems, special equipment and materials, kits of materials, films, programmed instruction - auto-tutorial materials, and supplementary reading materials. For teachers and curriculum designers, there are teachers guides, tests, evaluation procedures, and other special materials.

Teacher guides are an almost universal product of the curriculum studies at all school levels. The design and function of these teacher guides, however, vary according to the projects and according to the various school levels. At the primary and intermediate school levels, printed material is designed for the teacher as the principal guide to instruction, laboratory procedures, and activities. At the junior and senior high levels, these guides serve to supplement the text, laboratory manuals, and other instructional aids.

Student textbooks have generally not been produced at the primary and intermediate school level, although several curriculum studies have produced some written materials for students. At the junior high level, textbooks appear in most of the

curriculum studies, but the text is more of a guide to activities than an encyclopedic source of knowledge. At the senior high level, each of the major curriculum studies has produced at least one student textbook. The organization of these texts is based on intellectual schemes which closely represent the organizational schemes of the science. Several textbooks, each with different emphases of subject matter, have been produced by BSCS. The blue version, Biological Sciences: Molecules to Man, illustrates the approach to biology of the evolutionist, the molecular biologist, and the biochemist. The green version, High School Biology, illustrates the approach of the ecologist and the behaviorist. The yellow version, Biological Sciences: An Inquiry into Life, illustrates the approach of the cell physiologist, geneticist, and developmental biologist. Several studies have produced special textbooks for students of high and low ability levels. These are discussed later in this report.

Laboratory manuals have been produced for junior high school and senior high school curriculum projects and are designed to lead the student to question and to discover as well as to verify. Because the curriculum projects are organized around science as an investigational activity, the laboratory becomes the focal point of the course. And it is the laboratory guide which sets the pace for the course. Special equipment, research procedures, and laboratory blocks of instruction spreading over several weeks all have contributed to the change in the structure and function of the school laboratory.

Special equipment and kits have been produced by at least three of the elementary school studies. Kits containing materials used in both the instructional and evaluational aspects of the course have been produced by AAAS Science - A Process Approach. Kits of materials produced by the Elementary Science Project at Howard University are designed to be used by the student after school and/or at home and thus, necessarily contain instructions and instructional materials. The Elementary Science Study has produced a series of kits on differing topics such as "Butterflies," "Ice Cubes," and "Gasses and Airs." Each kit is complete in itself and provides materials and instructions for the particular study. The other elementary school curriculum studies are designed to use materials which are readily available in and around the classroom or can be easily obtained from the regular scientific supply houses.

At the junior high school level, kits of special materials have been produced by studies such as SSSP (Time, Space and Matter). In addition, various other projects such as Minnemast are producing materials and designing laboratory materials which are specific to the topic being studied. At the senior high level, specific laboratory materials, apparatus, and equipment have been designed, tested, and are being produced and marketed by various commercial firms.

In all of these cases, the breadth of materials produced is great, and it is up to the local teacher to decide which of these materials can be used most appropriately in the context of the local setting. Lists of such equipment are available from the directors of the curriculum projects.

Films and other audiovisual aids have been produced at the elementary school level by Minnemast and by the Elementary Science Study. At this level as well as at other levels, specific emphasis is given to the single-concept 8mm film which is relatively inexpensive. These films are usable directly by students as well as by teachers. Films and other instructional aids are available at the junior high level from SSSP (Time, Space and Matter), IPS (Introductory Physical Science), and other studies. Again, the burden of proper use of these materials rests with the teacher. At the senior high level, a wide selection of films and other audiovisual aids has been produced. These include a series of BSCS single-concept films, biological technique films as well as teacher training films. Similarly, the chemistry studies, CBA and CHEM, have produced films on chemical processes used in industry as well as films on various chemical concepts and theories. The various physics studies have produced single-concept films as well as full length films covering various laboratory procedures and classic experiments in the field of physics.

Programmed instruction materials have received scant attention in the curriculum studies. Such materials have been produced for only the senior high school level and, then, for only very limited aspects of the course; for example, The Use of a Slide Rule, a program produced by one of the chemistry studies.

Supplementary readings on subjects related to the particular curricular area have been produced in one of the junior high school studies, the Earth Science Curriculum Study, and in most of the senior high school studies. These readings are generally adapted from the classical investigations reported in the various disciplines and from interpretations of the investigational procedures used in research at the forefront of the various disciplines. These supplemental materials are intended for interested teachers and students. Usually a particular reading or pamphlet covers a specific area, but is broad enough and is detailed enough for the necessary development of a particular concept or concepts. Historical development of the concepts and their cultural implications are generally included. These supplementary readings emphasize the role of uncertainty and speculation, provide a clear discussion of the various processes of science, and emphasize the need for cooperation and communication within science and among scientists.

In a number of these publications such as in the BSCS series, unfinished and unexplored areas of research are frequently mentioned to prompt the student to further reading and speculation and perhaps action. These pamphlets are particularly useful in inservice workshops and as supplemental parts of certain classroom activities. These supplementary readings provide a rich source of reference materials. They are inexpensive and should be available in every appropriate classroom.

Materials for evaluating and testing student achievement have been developed by many of the curriculum projects. However, placing emphasis on the process aspect of science as well as on the product aspect compounds the problem of evaluation of student achievement. At the elementary school level, only the AAAS Science - A Process Approach has developed a systematic check list of behavioral competencies for use in measuring the student's understanding of the various processes of science. An evaluation kit is being designed to accompany the other AAAS materials. Minnemast has developed a series of tests appropriate to its materials. At the junior high level, tests of conceptual content and laboratory procedures have been developed by various groups such as IPS, SSSP (Time, Space and Matter), and ESCP (Earth Science Curriculum Project). At the senior high level, testing materials and procedures are being developed in most of the projects. In general, these testing materials become available when the project materials are produced by a commercial publisher. Tests of knowledge, concept attainment, laboratory procedures, and, in one case, a test of the processes of science are advertised as available and appropriate for a particular study.

Because the new curricula place particular emphasis on the process aspects of science, it follows that the evaluation programs should similarly place particular emphasis on these aspects. According to a BSCS publication, examinations should be designed to measure, in addition to knowledge, such qualities as those described in the Taxonomy of Educational Objectives by Bloom (1956) and should include tests of comprehension, application, analysis, synthesis, and evaluation. For a particular analysis of these points, see Evelyn Klinckmann "The BSCS Grid for Test Analysis," BSCS Newsletter No. 19, 1963. Because, in many cases, the person who controls the examination procedures in effect controls the curricular content, it is extremely important that the examinations be consistent with the objectives of the curriculum.

Guides for curriculum development and lists of teacher aids and laboratory materials have been prepared by the several curriculum groups and by various commercial laboratory supply houses. Additional materials prepared include such publications as the BSCS Materials for Preparation of In-Service Teachers of Biology, the BSCS bulletin series on "Biological Education in American Secondary Schools 1890-1960," A Guide to Working with Potential Biologists, and Implementation of BSCS in the Schools. The newsletters and/or quarterly reports produced by most of the curriculum studies, kindergarten through 12th grade, provide the teacher with a current summary of the developments in the many curriculum projects. Most of these are available free upon request to the directors of the various curriculum projects.

II ATTENTION TO SPECIAL PROBLEMS

Ability Grouping

The problem of special or restricted interests or abilities of students at the various grade levels has prompted the authors of the new science curricula to produce special materials and, in some cases, special courses to fit the needs of these groups. No special materials have been produced for these groups in the primary or intermediate grades. However, at the senior high school level, particular attention has been paid to the group of students with limited interests and/or abilities and low reading levels.

The Biological Sciences Curriculum Study has produced a set of special materials for "students who cannot adequately comprehend the regular version texts. These special materials have an even greater emphasis on laboratory activities and class discussions than the three regular versions.... The program has been developed so that the great majority of learning activities takes place directly in the classroom, because homework is generally avoided by these students."

The Physical Science Study Committee has developed a series of materials entitled "Introductory Physical Science" which is designed for use in the junior high school. However, IPS finds some additional use in the low ability groups in the senior high school.

Although the majority of the curriculum studies at the junior and senior high school levels are geared for courses of science in general education, certain of the courses, such as that of the Engineering Concepts Curriculum Study, are designed for the "average college-bound student."

The high ability student has available to him a wealth of materials produced through or in conjunction with the various curriculum studies in the form of supplemental readings and procedures of investigation. In the case of the BSCS biology program, invitations to inquiry and other materials of the laboratory block program have been developed into a second course, which is laboratory oriented and is designed for students who have successfully completed the basic course in biology. This advanced or second course provides firsthand investigational experiences for students in over 40 laboratory investigations, subject-matter explanations, and excerpts from the literature of biology. The Physical Science Study Committee advanced topics include such topics as angular momentum, relativity, statistical mechanics, quantum physics, and entropy. These units can be used to supplement the regular course or can be combined to form an advanced course for students with a particular interest and ability in physics.

Teacher Preparation

The demands placed upon the teacher for knowledge of curriculum objectives, techniques and/or subject-matter competence have increased the demands on the curriculum designers for leadership in this area. The directors of the curriculum programs have responded by instituting special programs of instruction. Academic year, summer, and inservice institute sponsored by the National Science Foundation have been set up to provide this special instruction. Special materials have been produced in the various courses to assist the teacher in developing laboratory techniques and instructional procedures appropriate to the program. Technique films, guides to laboratory procedures, and special laboratory equipment have been designed to assist the teacher in the performance of the instructional task. Inservice institutes organized at the local level provide an excellent means of updating and increasing the competency of the teachers in a local school system in developing and executing science curricula reforms. See further discussions in the following sections.

III WHERE TO LOOK FOR FURTHER INFORMATION

Each of the major curriculum studies is briefly summarized in the following pages. Further information on the availability of materials, the source and cost of publications, etc. can be obtained by writing to the project director. Descriptive brochures, newsletters, and quarterly reports are usually available and usually free. A brief request to the director that your name be added to the mailing list of the project is sufficient.

Specific help in adopting, modifying, and using the new science curricula is available from a number of sources in the state of Wisconsin.

1. The Supervisor of Science Education in the Department of Public Instruction is available to assist local school systems in such matters. Write to him in care of the Wisconsin Department of Public Instruction, Madison, Wisconsin.

2. Inservice workshops planned by the local school system can be sponsored jointly by the local system and the National Defense Education Act (NDEA) Title III. NDEA - Title III provides 50 percent of the consultant fee for such a workshop. For further information, write to NDEA Division, State Department of Public Instruction, Madison, Wisconsin.

3. Additional assistance may be obtained from the Department of Science Education at the several State Universities, the University of Wisconsin-Milwaukee, the University of Wisconsin-Madison, and the Director of Field Service, University Extension Division, Madison, Wisconsin.

Other sources of information such as curriculum reviews and reports of research studies are contained in the attached bibliography.

TABLE I

Curriculum Projects Relevant to Primary School Grades K-3

AAAS Commission on Science Education
John A. Mayor, Director
American Association for the Advancement of Science
1515 Massachusetts Avenue, N.W.
Washington, D. C.

Elementary Science Project
Joe C. Paige, Director
Howard University
Washington, D. C. 20001

Elementary Science Study
David Hawkins, Director
Educational Services Incorporated
108 Water Street
Watertown, Massachusetts 02172

Elementary School Science Project
Herbert L. Mason, Director
The University of California
2232 Piedmont Avenue
Berkeley, California 94720

Elementary School Science Project
John K. Wood, Director
Utah State University
Logan, Utah

Minnesota Mathematics and Science Teaching Project
James J. Wernts, Jr., Director
University of Minnesota
Minneapolis, Minnesota 55455

School Science Curriculum Project
Richard F. P. Salinger, Director
805 West Pennsylvania Avenue
Urbana, Illinois 61801

Science Curriculum Improvement Study
Robert Karplus, Director
University of California
Berkeley, California

TABLE II

Curriculum Projects Relevant to Intermediate School Grades 4-6

AAAS Commission on Science Education
John A. Mayor, Director
American Association for the Advancement of Science
1515 Massachusetts Avenue, N.W.
Washington, D. C.

Elementary Science Project
Joe C. Paige, Director
Howard University
Washington, D. C. 20001

Elementary Science Study
David Hawkins, Director
Educational Services Incorporated
108 Water Street
Watertown, Massachusetts 02172

Elementary School Science Project
Herbert L. Mason, Director
The University of California
2232 Piedmont Avenue
Berkeley, California 94720

Elementary School Science Project
J. Myron Atkin, Director
University of Illinois
805 West Pennsylvania Avenue
Urbana, Illinois 61801

Minnesota Mathematics and Science Teaching Project
James J. Werntz, Jr., Director
University of Minnesota
Minneapolis, Minnesota 55455

Science Curriculum Improvement Study
Robert Karplus, Director
University of California
Berkeley, California

School Science Curriculum Project
Richard F. P. Salinger, Director
805 West Pennsylvania Avenue
Urbana, Illinois 61801

TABLE III

Curriculum Projects Relevant to Junior High Schools

Earth Science Curriculum Project
Ramon Bisque, Director
P. O. Box 1559
Boulder, Colorado 80301

Elementary Science Study
David Hawkins, Director
Educational Services Incorporated
108 Water Street
Watertown, Massachusetts 02172

Elementary School Science Project
J. Myron Atkin, Director
University of Illinois
805 West Pennsylvania Avenue
Urbana, Illinois 61801

Introductory Physical Science
Physical Science Study Committee
Uri Haber-Schaim, Director
Educational Services Incorporated
164 Main Street
Watertown, Massachusetts 02172

Minnesota Mathematics and Science Teaching Project
James J. Werntz, Jr., Director
University of Minnesota
Minneapolis, Minnesota 55455

School Science Curriculum Project
Richard F. P. Salinger, Director
805 West Pennsylvania Avenue
Urbana, Illinois 61801

Secondary School Science Project
Frederick L. Ferris, Jr., Director
Princeton University
Princeton, New Jersey

TABLE IV

Curriculum Projects Relevant to Senior High Schools

Biological Sciences Curriculum Study, Biology Course
Special Materials and Second Course
William V. Mayer, Director
P. O. Box 930
Boulder, Colorado 80302

Chemical Bond Approach
Lawrence E. Strong, Director
Earlham College
Richmond, Indiana 47275

Chemical Education Material Study
George C. Pimentel, Director
Lawrence Hall of Science
University of California
Berkeley, California 94720

Engineering Concepts Curriculum Project
E. E. David, Jr., Director
Commission of Engineering Education
1501 New Hampshire Avenue, N.W.
Washington, D. C. 20036

Harvard Project Physics
Gerald Holton, Director
Harvard University
Cambridge, Massachusetts

Portland Project
Vernon Cheldelin, Director
Oregon State University
Corvallis, Oregon

Physical Science Study Committee, Physics Course
and Advanced Topics
Gerald R. Zacharias, Director
Educational Services Incorporated
164 Main Street
Watertown, Massachusetts 02172

Secondary School Science Project
Frederick L. Ferris, Jr., Director
Princeton University
Princeton, New Jersey

IV LISTING OF CURRICULUM STUDIES

The materials listed under each of the following studies are exemplary of those being produced by the project. Write to the project director for a complete listing of materials available for purchase.

1. AAAS Science - A Process Approach

AAAS Commission on Science Education
John A. Mayor, Director
American Association for the Advancement of Science
1515 Massachusetts Avenue, N.W.
Washington, D. C.

Rationale:

Science - A Process Approach, developed by the AAAS Commission on Science Education, emphasizes the development of competence in skills basic to further learning. According to the Commission: "The child is introduced to a variety of content in acquiring these skills -- he learns about plants and animals and rocks and weather and solutions of chemicals and the motion of objects. The content he learns is not systematically related to particular scientific disciplines, but is considered to be derived from more-or-less familiar objects and phenomena in the world around him. Our hope is that by the end of the third grade, the child who has been instructed by means of these exercises has acquired some important fundamental process skills, a good many basic scientific concepts, and some organized knowledge about the natural world."

The assumption is made that science is much more than an encyclopedic collection of facts and that children in the primary grades will benefit from experiences which enable them to acquire an ability to apply certain processes that are essential to the study of science. These processes have been identified as: 1) recognizing and using space/time relations, 2) recognizing and using numbers and number relations, 3) observing, 4) classifying, 5) measuring, 6) communicating, 7) inferring, 8) predicting. In the intermediate grades, children acquire the use of more complex and integrated process abilities which are an extension and an elaboration of the process skills developed in the primary grades.

Grade: K - 6

Materials produced:

Classroom laboratory guides
(Science - A Process Approach, Parts 1 through 6)

Equipment kits

Kits for testing and evaluation

Commentary for Teachers

Commission on Science Education - Newsletter

2. BSCS Biology Course

Biological Sciences Curriculum Study
William V. Mayer, Director
P. O. Box 930
Boulder, Colorado 80302

Rationale:

The Biological Sciences Curriculum Study emphasizes biology as a modern experimental science. The materials produced are based on nine themes, which include 1) science as inquiry, 2) the intellectual history of biological concepts, 3) change of living things through time: evolution, 4) diversity of type and unity of pattern and living things, 5) the genetic continuity of life, 6) complementarity of organisms and environment, 7) biological groups of behavior, 8) complementarity of structure and of function, 9) regulation and homeostasis.

The instructional focus of the course is the laboratory which is closely integrated with the textual materials.

Grade: 10

Materials produced:

Films: single concept and technique

Guides for inservice programs

Laboratory blocks

Newsletter

Research problems

Student texts (Blue Version - Biological Science: Molecules to Man; Green Version - High School Biology; Yellow Version - Biological Science: An Inquiry into Life.)

Teacher guides for texts

Teacher guides to laboratory technique

Teacher handbook

Tests

3. BSCS Biology - Second Course

Biological Sciences Curriculum Study
William V. Mayer, Director
P. O. Box 930
Boulder, Colorado 80302

Rationale:

The second course entitled Biological Science: Interaction of Experiments and Ideas is designed for the student who has successfully completed a basic course in biology, preferably one of the three BSCS versions, and who exhibits a strong desire for a more intensive study of experimental biology. A primary goal of the course is to provide firsthand investigational experiences so that students will gain an understanding of science. The major theme, "Science as Inquiry," is developed by over 40 laboratory investigations, subject matter explanations, excerpts from the literature of biology, applications of simple biometrics, and selected "Invitations to Inquiry."

Grade: 12

Materials produced:

Newsletter

Student text (Biological Science: Interaction of Experiments and Ideas)

Teachers' guide

(Also see BSCS-biology materials.)

4. BSCS Special Materials

Biological Sciences Curriculum Study
William V. Mayer, Director
P. O. Box 930
Boulder, Colorado 80302

Rationale:

The Biological Sciences Curriculum Study's Special Materials have been designed for "the student who cannot adequately comprehend the regular version texts." These materials "have a greater emphasis on laboratory instructions, short paragraphs of reading materials, illustrations and quizzes. Because of the special role of the teacher, the primary publication is the special materials teachers manual."

Grade: 9, 10

Materials produced:

Newsletter

Student text (Biological Science: Patterns and Processes)

Teacher's manual

(Also see BSCS biology materials)

5. CBA

Chemical Bond Approach
Lawrence E. Strong, Director
Earlham College
Richmond, Indiana 47375

Rationale:

The Chemical Bond Approach was designed as an introductory course in chemistry with emphasis on laboratory experiments. The text, students' and teacher's laboratory guides, and examinations as well as a set of readings from the Journal of Chemical Education have been produced. The project is currently considered to be complete.

Grade: 11, 12

Materials produced:

Newsletter

Student text (Chemical Systems)

Teacher's guide

Student laboratory guide (Investigating Chemical Systems)

Teacher's laboratory guide

Tests

Supplemental readings

Programmed instruction materials

6. CHEM

Chemical Education Material Study
George C. Pimentel, Director
Lawrence Hall of Science
University of California
Berkeley, California 94720

Rationale:

The objectives of CHEM Study include: 1) to further in those students who will not continue the study of chemistry after high school an understanding of the importance of science in current and future activities, 2) to encourage teachers to undertake further study of chemistry courses that are geared to keep pace with advancing scientific frontiers and, thereby, to improve their teaching methods, 3) to guarantee the existence in the near future of a variety of excellent high school chemistry texts significantly influenced by CHEM Study, but produced under normal author-publisher relationships. "CHEM Study materials are organized around the laboratory which is the focus of activities for the entire course."

Grade: 11 or 12

Materials produced:

Newsletter

Student textbook (Chemistry and Experimental Science)

Student laboratory manual

Teacher's guide

Films

Tests

Programmed instruction materials

---

7. ECC - Engineering Concepts Curriculum

Engineering Concepts Curriculum Project
E. E. David, Jr., Director
Commission of Engineering Education
1501 New Hampshire Avenue, N.W.
Washington, D. C. 20036

Rationale:

The Engineering Concepts Curriculum Project is designed to introduce into the high school curriculum engineering concepts dealing with man in his man-made world. The course is designed to fill the gap between idealized laws of nature (in the existing courses) and the devices, systems, processes, and structures which populate today's world. Subjects include a discussion of man and computors, logic circuits with memory, use of the computor, sensing and measuring, dynamical systems, and energy control and design. According to information provided by ECCP, this course will be "suitable for the average college-bound high school student."

Grade: 12

Materials produced:

Commission on Engineering Education Reports (Newsletter)

Preliminary version of text (The Man-Made World)

8. ESCP - Colorado

Earth Science Curriculum Project
Ramon Bisque, Director
P. O. Box 1559
Boulder, Colorado 80301

Rationale:

The Earth Science Curriculum Project is an experience-centered study of materials from astronomy, geology, physical geography, geophysics, meteorology and oceanography. One of the major concerns has been that ESCP courses not be a series of disconnected units, but rather an integrated study which will give the student a broad understanding of the planet earth as a system. The course is developed around two unifying themes - the hydrologic cycle and the rock cycle. The course begins with a study of the sun as the source of energy and continues with studies of the interaction between this energy and the liquid and gaseous envelopes of an unequally heated and rotating earth. The deposition of sediment forms a natural link with the rock cycle, ultimately with geologic history, and with the account of the evolution of land forms.

Grade: 9, and with some relevance to 7 - 12

Materials produced:

ESCP Newsletter

Student text
(Investigating the Earth)

Laboratory manual

Teachers' guide

Supplementary reading

Visual materials and models are planned

9. ESP - Howard

Elementary Science Project
Joe C. Paige, Director
Howard University
Washington, D. C. 20001

Rationale:

The Elementary Science Project has been primarily concerned with the production of science units or kits (a self-contained package of materials and guides) which are provided to the student for use outside school, usually at home. The program reaches both the student and his parents. "This program of compensatory science experiences for disadvantaged children (K-6) and their parents has been developed in an effort to help overcome the social and personal handicaps which usually attend such privations."

Grade: K - 6

Materials produced:

Elementary science activity kits

10. ESS - ESI

Elementary Science Study
David Hawkins, Director
Educational Services Incorporated
108 Water Street
Watertown, Massachusetts 02172

Rationale:

"The purpose of the Elementary Science Study is not to develop a national curriculum but to supply a variety of carefully thought out and tested materials which the Curriculum Director of a school system may use in developing an elementary science curriculum for the particular needs of his school system. Materials selected for study are those which inherently allow for a flow of ideas originating from the curiosity of children. Things that lead to certain fundamental notions: BUTTERFLIES, CELLS, GASSES AND AIRS, KITCHEN PHYSICS, MOLDS, PLAYGROUND PHYSICS, etc. are studied. The materials developed are trial taught with children varying in intelligence, social economic background, and age. The purpose of the project is primarily that of developing more meaningful materials with little emphasis given toward development of a sequential or continuing program with specific structure as to grade level."

Grade: K - 8

Materials produced:

Newsletter	Student experimental sheets
Kits or units	Apparatus and materials
Teacher guides	Films, film loops

11. ESSP - California

Elementary School Science Project
Herbert L. Mason, Director
The University of California
2232 Piedmont Avenue
Berkeley, California 94720

Rationale:

The Elementary School Science Project is developing and testing curriculum materials on basic science for the elementary school. These materials or units, not restricted to particular grade levels, include "How I Began" (a comparative study of the development of human and chick embryos) and "Coordinates" (graphs and equations). These materials can be selected and used where appropriate in developing the science curriculum.

Grade: 1 - 6

Materials produced:

Teacher manuals for each unit

12. ESSP - Illinois Astronomy

Elementary School Science Project
J. Myron Atkin, Director
University of Illinois
805 West Pennsylvania Avenue
Urbana, Illinois 61801

Rationale:

The objective of the Illinois Astronomy Project (ESSP) is the production of curricular materials that are sound astronomically, that reflect the structure of the subject as it is viewed by astronomers of stature, and that can be handled by teachers and children in actual classrooms. Such topics as charting the universe, the

message of starlight, and galaxies and the universe provide the subject matter for the course.

Grade: 5 - 8

Materials produced:

Student texts (Charting the Universe, The Universe in Motion, Gravitation, The Message of Starlight, The Life Story of a Star, The Galaxies and the Universe)

Teacher guides

13. ESSP - Utah

Elementary School Science Project
John K. Wood, Director
Utah State University
Logan, Utah

Rationale:

The principle theme of the Utah Elementary School Science Project "is to develop observational awareness on the part of the child so that he may probe the puzzles of nature by observing, comparing and measuring." Attributes of objects such as color, shape, size, temperature, and other observables are studied to discover interactions and relationships. Several tests of psychological concept development have been produced. The course is designed to implement the teaching of process and product at the first grade level.

Grade: 1 and 2

Materials produced:

ESSP Newsletter

Teacher manuals for science in grades 1 and 2
(Science for the First Grade, Science for the Second Grade, Biological Supplements)

14. HPP - Harvard

Harvard Project Physics
Gerald Holton, Director
Harvard University
Cambridge, Massachusetts 02138

Rationale:

Harvard Project Physics was formed to develop a new kind of physics course, one that is appealing and instructive to a wide variety of students, from the science-oriented to the science-shy. In an effort to help check the continuing drop in the proportion of students who are taking physics in high school, an attempt is being made to treat physics as a lively and fundamental science and also as an activity that is closely related to the achievements both in other sciences and in fields other than science itself. Although this physics course is centered on a solid introduction to physics including some of its recent developments, the humanistic background of the sciences is stressed. In an effort to attract substantial numbers of students, HPP is developing a range of teaching aids, including teachers' guides to texts and laboratory equipment, programmed instruction, pupil tests, laboratory manuals, film loop slides, a book of selected readings, and a number of films and paperback monographs.

Grade: 12

Materials produced:

Student text	Newsletter
Teachers' guide to text	Programmed instruction
Teachers' guide to laboratory equipment	Tests
Laboratory manuals and films	Supplementary readings

15. IPS

Introductory Physical Science
Physical Science Study Committee
Uri Haber-Schaim, Director
Educational Services Incorporated
164 Main Street
Watertown, Massachusetts 02172

Rationale:

"The theme of the (Introductory Physical Science) course is the development of evidence for the atomic model of matter. The laboratory experiments are contained in the body of the text and must be carried out by the student for a proper understanding of the course. Many of the conclusions and generalizations arrived at as a result of doing the experiments become essential parts of the complete text. Although laboratory space is always an asset, the experiments in the course have been successfully performed in classrooms with individual flat desk tops and only one sink." Included are such topics as quantity of matter: mass; characteristic properties; and the separation of substances.

Grade: 7, 8, 9

Materials produced:

Student text	Tests
Teachers' guide	Drill and quiz problems
Laboratory equipment and apparatus	

16. Minnemast

Minnesota Mathematics and Science Teaching Project
James J. Werntz, Jr., Director
University of Minnesota
Minneapolis, Minnesota 55455

Rationale:

Minnemast is engaged in producing a coordinated mathematics and science program for kindergarten through ninth grade and supportive preservice and inservice courses in content and pedagogy. The science units focus attention on operations in science such as developing notational systems, classifying, and measuring.

Grade: K - 9

Materials produced:

Teacher manuals	Tests

Materials (continued):

Films

Minnemast quarterly reports

Materials for methods courses

17. Portland Project

Portland Project
Vernon Cheldelin, Director
Oregon State University
Corvallis, Oregon

Rationale:

The objective of the Portland Project is to develop and test a two-year integrated secondary school physics-chemistry course utilizing content and materials developed by CBA, CHEMS, and PSSC. Testing materials from PSSC, CHEM, and CBA were utilized in the production of unified tests appropriate to the integrated courses. No further work is planned.

Grade: 11 - 12

Materials produced:

Integrated student guides (PSSC-CBA; PSSC-CHEM)

Integrated teacher guides

Integrated tests

Materials available: $2.50 for complete set

The Curriculum Center
Portland Public School District
631 N. E. Clackamas
Portland, Oregon

18. PSSC - ESI Advanced Topics

Physical Science Study Committee - Advanced Topics
Uri Haber-Schaim, Director
Educational Services Incorporated
164 Main Street
Watertown, Massachusetts 02172

Rationale:

The objective of the Physical Science Study Committee - Advanced Topics is the preparation of advanced topics which may be used in conjunction with the PSSC Physics Course or as a separate advanced course. These topics include angular momentum, relativity, statistical mechanics, quantum physics, and entropy.

Grade: 12

Materials produced:

Student texts

Teacher guides

Tests

Equipment for laboratory

Films

Laboratory guide

ESI Quarterly Reports

19. PSSC Physics Course

Physical Science Study Committee, Physics Course
Gerald R. Zacharias, Director
Educational Services Incorporated
164 Main Street
Watertown, Massachusetts 02172

Rationale:

"Physics is presented not as a body of facts but basically as a continuing process by which men seek to understand the nature of the physical world." Major emphasis is placed on the use of the laboratory integrated with the content development in the course. PSSC emphasizes conceptual physics as: time, space, matter, wave motion, Newtonian mechanics, and electricity and atomic structure.

Grade: 12

Materials produced:

Student text (Physics)
Laboratory guide
Teacher resource book & guide
Laboratory apparatus
Films
Supplemental reading series
Tests
ESI Quarterly Reports

20. SCIS - California

Science Curriculum Improvement Study
Robert Karplus, Director
University of California
Berkeley, California

Rationale:

The California Science Curriculum Improvement Study is characterized by two features: 1) extensive direct contact of the children with natural phenomena so that as much information as possible is gathered by the children through their own observations (Little is told them by their teachers or by their books.), 2) slow accumulations of abstractions in a hierarchy, with broad concepts being introduced early and more sophisticated distinctions being made later. Beginning with such abstractions as the concepts of living and non-living matter, conservation of matter, and variation of one property among objects with similar properties, the project continues to higher levels of abstractions such as interactions, relativity, conservation of energy, equilibrium, and behavior and evolution of living organisms. Throughout all of these the student is an active participant. Thus these topics cover areas of biology, chemistry, physics, and the earth sciences.

Grade: K - 6

Materials produced:

Teacher guides (Variation in Measurement, Systems, Interaction, Relativity of Position and Motion, Subsystems)

SCIS Newsletter

21. SSCP - Illinois

School Science Curriculum Project
Richard F. P. Salinger, Director
805 West Pennsylvania Avenue
Urbana, Illinois 61801

Rationale:

The major objective of the Illinois School Science Curriculum Project is to produce a series of science curriculum materials for use in grades K - 9. Such units as Measurement and Graphing, Ants: Their Life Cycles, Coulomb's Law and Running Water, and River Development are typical of those produced and can be selected for inclusion in the curriculum at the local level.

Grades: K - 9

Materials produced:

Teacher manuals for the 25 units produced

22. SSSP - Princeton Geology Project - Time, Space, Matter

Secondary School Science Project
Frederick L. Ferris, Jr., Director
Princeton University
Princeton, New Jersey

Rationale:

The objective of the Princeton Secondary Science Project (Time, Space and Matter) is to "develop a program for secondary school grades centered on geology that will lead students through a series of their own interrelated sequential investigations, direct observation, and inference to an understanding of the nature of the earth."

"Through his experience with (the text) Time, Space and Matter, the student encounters learning situations designed to facilitate both his acquisition of knowledge and his acquisition of the motivation to learn with enthusiasm." The student is at the center of action and of the manipulation of materials; he makes things happen and yet is a part of structured discovery.

The strategy of Time, Space and Matter is to structure the learning situation to maximize the opportunities for the student to arrive at an understanding of the nature of the physical world and of science as a method of inquiry, through his own firsthand experience.

Grades: 9 - 12

Materials produced:

- Student texts (Time, Space and Matter)
- Laboratory kits
- Progress reports
- Teacher guides
- Laboratory guides
- Tests
- Films

V BIBLIOGRAPHY

Abraham, Norman. "The Interaction of Experiments and Ideas: A BSCS - Second Course." Journal of Research in Science Teaching 2:60, 1964.

Alexander, R. L. "Visioelastic Models in the Physics Curriculum." Physics Teacher 3:350-354, 8; November, 1965.

Alexander, William M. Changing Curriculum Content, Washington, D. C.: ASCD Commission on Curriculum Development, ASCD, 1964.

Amaro, A. "Considerations upon the BSCS (Green Version)." The American Biology Teacher; May, 1964.

Armstrong, J. A. "Science for the Terminal Student." Journal of Secondary Education 41:65-70; February, 1966.

Ashton, M. D. "Traditional and BSCS Biology." Catholic Education Review 64:190-195; March, 1966.

Atkin, J. Myron. "Science in the Elementary School; Curriculum Development." Review of Educational Research 34:266-269; June, 1964.

_____. "University of Illinois Elementary School Science Project - 1964." Journal of Research in Science Teaching 2:328; 1964.

_____ and Karplus, Robert. "Discovery or Invention?" The Science Teacher 29:45; September, 1962.

Beckel, C. L. "A Review of Science Curriculum Developments in the United States." Science Education (Taiwan); 1964.

Berlin, B. M. "New General Science Curriculum Features Direct Experimentation; Secondary School Science Project Vitalizes General Science." Chicago School Journal 46:63-67; November, 1964.

Blackwood, Paul E. Science, Washington, D. C.: ASCD, 1963. Chapter 7, "Using Curriculum Developments," A Report of the ASCD's Commission on Current Curriculum Developments.

Bloom, Benjamin S., editor. Taxonomy of Educational Objectives, New York: Longmans, Green, 1956.

Bowden, A. E. "Evaluating the Curriculum." Ohio Schools 43:13; December, 1965.

Brakken, Earl. "Intellectual Factors in PSSC and Conventional High School Physics." Journal of Research in Science Teaching 3:19; 1965.

Brauder, O. L. "Attempts to Improve High School Physics Education." Science Education 47:372-376; October, 1963.

_____. "Conventional Physics against PSSC Physics." Science Education 49:170-171; March, 1965.

_____. "Something Dangerously New in Physics Teaching." Science Education 47:365-372; October, 1963.

Brierley, J. K. "The Biological Sciences Curriculum Study Publications," Science; February, 1964.

Busch, James W. "New Directions in Science Teaching," Wisconsin Journal of Education; December, 1960.

Butterfield, Charles and White, Preston. "New High School Biology in the Light of Experience" (Letter to the Editor). Science; May 15, 1964.

Cain, Ralph Winston. An Analysis of the Achievement of Students in Selected High School Biology Programs in Relation to Their Mathematical Aptitude and Achievement, (Doctoral Dissertation). University of Texas; August, 1964.

_____ and Lee, Eugene C. "An Analysis of the Relationship between Science and Mathematics at the Secondary School Level." School Science and Mathematics; December, 1963.

Calandra, Alexander. "The New Science Curriculum, A Sharp Dissent." School Management; November, 1964.

Chapman, J. M. and Caldwell, L. T. "Content Study of Earth Science Courses in Selected Secondary Schools." Science Education 48:430-436; December, 1964.

Cheldelin, Vernon H. and Fiasca, Michael. "A Synthesis of the New Curricula in Physics and Chemistry for the Secondary School." Journal of Research in Science Teaching 2:283; 1964.

Colby, Edward. "The New Science Curriculum, A Loud Hurrah." School Management; November, 1964.

Cunningham, J. D. "New Developments in Elementary School Biology; Science Curriculum Improvement Study." American Biology Teacher 28:193-195; March, 1966.

Dartnell, W. W. "In Defense of PSSC." (Letters to the Editor). Physics Teacher 3:371,378; November, 1965.

Duckworth, Eleanor. "The Elementary Science Study Branch of Educational Services Incorporated." Journal of Research in Science Teaching 2:241; 1964.

Educational Services Incorporated. ESI Quarterly Report. Watertown, Massachusetts: Educational Services Incorporated; 1965 - Summer-Fall.

Fehr, H. "Role of Physics in the Teaching of Mathematics." Math Teacher 56:394-399; October, 1963.

Ferris, Frederick L. "The Princeton Junior High School Science Project." Journal of Research in Science Teaching 1:281; 1963.

Fiasca, M. and Porter, D. "Portland Tries Integrated Science Course." Science Teacher 31:39; February, 1964.

Fish, A. S. "Evaluating New Programs in Math and Science." School Science and Mathematics 65:531-533; June, 1965.

Francis, Brother C. and James, Brother F. "Overhead Projection Applications for Some PSSC Material." Physics Teacher 2,6:278-281; September, 1964.

Francis, G. M. and Hill, C. W. "Unified Program in Science for Grades Nine through Twelve." Science Teacher 33:34-38; January, 1966.

Gagné, R. M. "A New Scheme of Instruction" (Reply J. M. Atkin). Science 51:103; March 4, 1964.

George, Kenneth D. "The Effect of BSCS and Conventional Biology on Critical Thinking." Journal of Research in Science Teaching 3:293; 1965.

Gibboney, R. A. and OTHERS. "Curriculum Components and Organization." Physics Review of Educational Research 33:281-283.

Glass, Bentley. "Advancing Science" (Letters to the Times). The New York Times; July 16, 1960.

_____. "The Biology Teacher in a Racing World." School Life; October, 1962.

_____. "Information Crisis in Biology." Bulletin of the Atomic Scientists; October, 1962.

_____. "A New High School Biology Program." American Scientist; December, 1961.

_____. "Renascent Biology." The School Review; December, 1961.

Goodlad, John I. School Curriculum Reform in the United States. New York: The Fund for the Advancement of Education; 1964.

Grobman, Hulda. "Biological Sciences Curriculum Study of the American Institute of Biological Sciences." Science Education News; 1960.

_____. "High School Biology: On What Grade Level Does It Belong?" Clearing House 38:498-499; April, 1964.

_____. "How Do We Get Better Science Teaching?" The Bulletin of the National Association of Secondary-School Principals; February, 1961.

_____. "Identifying the 'Slow Learner' in BSCS High School Biology." Journal of Research in Science Teaching 3:3; 1965.

_____. "A New Curriculum in Biological Sciences." Educational Leadership; March, 1961.

_____. "Student Performance in New High School Biology Programs." Science; January 17, 1964.

_____. "A Study in Educational Improvement." The Clearing House; November, 1961.

_____. "Who Is the Slow Learner in Biology." FAST Journal (Florida Association of Science Teachers); April- May, 1964.

Gruver, W. J. "Can Your School Afford the New Science Programs?" School Life 46:5-7; January, 1964.

Hawkins, David. "Messing About in Science." Science and Children 2:5,5; 1965.

Heath, Robert W. "Comparison of Achievement in Two Physics Courses." Journal of Experimental Education 32:347-354; 1964.

_____. "Curriculum, Cognition, and Educational Measurement." Education and Psychology Manual 24:239-253; 1964.

_____. New Curricula. New York: Harper and Rowe Publishers, 1964. 284 pp.

_____ and Stickell, D. W. "CHEM and CBA Effects on Achievement in Chemistry." The Science Teacher 30:5; 1963.

Heller, Robert L. "The Earth Science Curriculum Project - A Report on Progress." Journal of Research in Science Teaching 2:330; 1964.

_____. "The Earth Science Curriculum Project." Journal of Research in Science Teaching 1:272; 1963.

Hernandez, Delores. "Invitations to Inquiry." Improving the Teaching of Science for Developing the Skills of Inquiry and Creative Thinking. Yearbook, Philippines: Philippine Association of Science Teachers, 1963.

Herrman, J. J. "What Problems Are Involved in Implementing the New Curricular Programs?" Arithmetic Teacher 12:575-577; November, 1965.

Hoffmaster, E. S. "Design for Science; A Theoretical Model." Science Teacher 31:15-17; November, 1964.

Holton, G. "Physics and Culture: Definition of Goals, and Proposals for Science Instruction." Superior Student 50:1-21; September, 1963.

Hughes, T. W. "The New Curricula." Curriculum News (Education Department of Tasmania); August, 1962.

Humphrey, D. G. "New Day in Biology Teaching." Improving College and University Teaching 13:74-75; September, 1965.

Hurd, Paul deH. "The Controversy about Science Teaching." AIBS Bulletin; 1959.

Hutchisson, E. "Physics in Our High Schools - A National Problem." Physics Teacher 2,8:385-387; November, 1964.

Ivo, Sister Mary, B.V.M. "The Catholic High School and the BSCS Program." The American Biology Teacher; May, 1962.

Jarvis, O. T. "Arithmetic and Science Time Allotment in Intermediate Grades." School Science and Mathematics 66:322-324; 1966.

Joan, Sister M., P.H.J.C. "Chemistry Approach to Biology." School Science and Mathematics; February, 1964.

Johnson, P. G. "National Developments in Science Curriculum in Elementary and Junior High Schools." School Life 45:27-30; October, 1962.

Journal of Chemical Education. "Changing Chemistry Curriculum" (Symposium). The Journal 43:112-123; March, 1966.

Karplus, Robert. "Beginning a Study in Elementary School Science." American Journal of Physics 30; 1962.

_____. Coordinates. Berkeley: Elementary School Science Project, University of California, Berkeley; 1959.

_____. Force. Berkeley: Elementary School Science Project, University of California, Berkeley; 1959.

_____. Meet Mr. O. Maryland: Department of Physics and Astronomy, University of Maryland; March, 1963.

_____. "Meet Mr. O." Science and Children 1:19; October, 1963.

_____. "One Physicist Looks at Science Education." Intellectual Development: Another Look. Washington, D. C.: Association for Supervision and Curriculum Development; 1964.

_____. "Science Curriculum Improvement Study." Journal of Research in Science Teaching 2:293; 1964.

_____. "The Science Curriculum--One Approach." Elementary School Journal 62:243; 1962.

_____ and Thies, H. D. "Science Curriculum Improvement Study." The Instructor 74:43-84; January, 1965.

King, A. R. and Brownell, J. A. "Monolithic Theories of the Curriculum." Excerpt from Curriculum and the Disciplines of Knowledge. School and Society 94:190-198; April, 1966.

Klinge, P. "Resources for Improving Instruction in Biology." School Life; October, 1962.

_____. "Worried Physicists." American Biology Teacher 28:244; April, 1966.

Lee, Addison E. "Biology Laboratory Instruction Innovation." The Science Teacher; October, 1961.

_____. "The Block of Time Idea in Biology Laboratory Instruction." The American Biology Teacher; 1960.

Leiderman, G. F. "Mathematics and Science Programs for the Elementary School Years." Review of Educational Research 35:154-162; April, 1965.

Lerner, M. R. "Integrated Science; Physics and Chemistry." The Science Teacher 31:37-38; July, 1964.

Lightner, Jerry P. "The BSCS and Advanced Biology." The American Biology Teacher; May, 1964.

Lisonbee, Lorenzo. "Teaching Science to the Disadvantaged Pupil." The Science Teacher; October, 1963.

_____ and Fliegler, L. A. "BSCS and the Slow Learner." American Biology Teacher 26:334-337; May, 1964.

_____ and Fullerton, B. J. "Comparative Effects of BSCS and Traditional Biology on Student Achievement." School Science and Mathematics 64:594-598; October, 1964.

Livermore, Arthur H. "A Process Approach of the AAAS Commission on Science Education." Journal of Research in Science Teaching 2:271; 1964.

_____. "AAAS Commission of Science Education." Journal of Research in Science Teaching; 1964.

Lockard, J. D. "Secondary School Curriculum Projects." The Science Teacher 32:48-49; May, 1965.

Loretta, Sister M. "The Difficulty of High School Physics." Physics Teacher 3,3: 119; March, 1965.

Lundstrom, D. and Lowery, L. "Process Patterns and Structural Themes in Science." The Science Teacher 31:16-19; September, 1964.

MacMahan, H., Jr. "Princeton Project or ESCP: A Difficult Choic " School Science and Mathematics 66:86-91; January, 1966.

Marie, Sister Julia, O.S.F. "Teaching Biology in High School - A Critique of the BSCS Green Version." Catholic School Journal; October, 1962.

Martin, W. Edgar. "Planning Facilities for High School Biological Sciences." School Board Journal; July, 1962.

Mayer, William V. "The Impact of Testing on New Curricula." The American Biology Teacher; December, 1964.

_____. "Science Curriculum Changes." Education Quarterly (Philippines); August, 1964.

Mayer, William V. "Teaching Science as Inquiry: A Total Program Involving Text, Laboratory, Discussions and Examinations." Education Quarterly (Philippines); August, 1964.

McKibben, Margaret J. "Study of New Developments in Secondary School Science, Grades 7-12." Science Education; December, 1961.

Metzner, Jerome. "The Gifted Student Program of the BSCS." The American Biology Teacher; May, 1964.

Miller, Bruce. "New Curricula in Science Teaching." The Bulletin (Madison, Wisconsin Education Association); January, 1963.

Morlan, G. E. "Experiments with the CBA Chemistry." School Science and Mathematics 65:425-431; May, 1965.

National Academy of Sciences. "Appendix D, Biological Sciences Curriculum Study." Guidelines for Development of Programs in Science Instruction, the Academy, 1963.

National Association of Secondary-School Principals. "Checklist for Evaluating a Biology Laboratory." The Bulletin of the NAS-SP; November, 1961.

National Catholic Education Association. "Biology for Slow Learners." Pointers for Principals, the Association; May, 1964.

National Council for Geographic Education, Earth Science Committee. "Role of Geography in the Earth Sciences." Journal of Geography 63:101-108; March, 1964.

Nichols, Benjamin. "Elementary Science Study: Two Years Later." Journal of Research in Science Teaching 2:288; 1965.

Novak, Alfred. "Scientific Inquiry in the Laboratory." The American Biology Teacher; May, 1963.

_____ and Abraham, Norman. "Excellence in Biology Facilities." The Science Teacher; 1962.

Novak, Joseph D. "Biological Education in American Secondary Schools 1890-1960." (Book Review). The American Biology Teacher; January, 1962.

Paldy, Lester G. "Science, Humanism, and High School Physics." Physics Teacher 3,2:75-77; February, 1965.

Perrott, Elizabeth. "BSCS Biology Course." The Times Educational Supplement (London); May 3, 1963.

Physics Teacher. "The High School Physics Course: A Symposium." Physics Teacher 4:218-224,5; May, 1966.

Pierce, Gale. "The University of Illinois Elementary-School Science Project: Report of the 1963 Writing Conference." Journal of Research in Science Teaching 1:270; 1963.

Pode, J. S. F. "CBA and CHEM Study: An Appreciation." Journal of Chemistry Education 43:98-103; February, 1966.

Poorman, G. "Indiana Physics Teachers React to PSSC." Science Education 49:171-172; March, 1965.

Rainer, W. B. "Meeting the Challenge of Recent Developments in Science in Assessing the Objectives of Modern Instruction." School Science and Mathematics 66:335-341; April, 1966.

Rainey, R. G. "Comparison of the CHEM Study Curriculum and a Conventional Approach to Teaching High School Chemistry." School Science and Mathematics 64:539-544; June, 1964.

Rasmussen, D. "SAM: A Correlated Sequence in Science and Mathematics." Science Teacher 31:36-38; April, 1964.

Reznikov, L. I. "Paths of Development of the Content and Structure of Secondary School Physics Course." Soviet Education 6:53-59; March, 1964.

_____. "Physics Course in the Secondary School." Soviet Education 7:36-44; November, 1964.

Richards, A. Glenn. "The Interdependence of Structure and Function." The American Biology Teacher; November, 1961.

Rosenbloom, P. C. "The Minnesota Mathematics and Science Teaching Project." Journal of Research in Science Teaching 1:276; 1963.

Salinger, R. F. P. "Progress Report: The School Science Curriculum Project." Science Teacher 33:37-39; January, 1966.

Sanders, Norris. Classroom Questions - What Kinds. New York: Harper and Rowe, 1966. 173 pp.

Schmidt, D. J. and Smith, D. D. "Innovations in Secondary Biology Instruction." School Science and Mathematics 66:325-330; April, 1966.

School Management. "The 'New' Science Curriculums: How to Get Your District Ready." School Management; June, 1963.

_____. "Where to Get Help for Your School District." School Management; September, 1961.

Schultz, R. W. "Building a Science Curriculum." NEA Journal 53:21-23; October, 1964.

Schwab, J. J. Materials and Techniques in Four Curriculum Areas. (Published weekly.) April, 1961.

Science Curriculum Improvement Study. Newsletter, 1; January, 1964.

Scott, Lloyd F. "An Experiment in Teaching Basic Science in the Elementary School." Science Education 46:105; 1962.

_____. "UCESSP: An Experiment in Discovery." Journal of Research in Science Teaching 2:364; 1964.

_____. "The University of California Elementary School Science Project: A Two-Year Report." Science Education 46:109; March, 1962.

Shamus, Brother C.F.X. "A High School Physics Survey." Physics Teacher 3,3:1214; March, 1965.

Shea, J. H. "Earth Science Curriculum Project; A Progress Report." Science Teacher 32:43+; February, 1965.

Siedband, J. "Physical Curricula and Teachers." (Letter to Editor). Physics Teacher 4:175,4; April, 1966.

Smith, C. "Impact of the New National Science Curricula on the Established Science Program." The American School Board Journal 152:14-16; February, 1966.

Smith, G. "PSSC Applied Physics." Physics Teacher 3,7:312+; October, 1965.

Smith, Herbert A. "Educational Research Related to Science Instruction for the Elementary and Junior High School: A Review and Commentary." Journal of Research in Science Teaching 1:199; 1963.

Smith, Herbert A. "Research and Science Education." Journal of Research in Science Teaching Vol. 1, No. 3; 1963.

Soviet Education. "Conference on the Content of the School Physics Course." Soviet Education 6:49-52; March, 1964.

_____. "Curriculums and Syllabuses for the Eight-Year and Secondary Schools." Soviet Education 7:16-26; November, 1964.

_____. "On the Draft of a New Program for General Biology." Soviet Education 8:15-27; January, 1966.

Stephenson, R. C. "Earth Science Curriculum Project; Its Organization, Objectives and Philosophy." Science Teacher 31:21-23; March, 1964.

Stewart, Maron. "Goals of Secondary School Teachers." Science; March 24, 1961.

Strasser, B. B. "Geology in Elementary Science." The Instructor 75:24+; January, 1966.

Sutton, R. M. "Elementary School Science Project, University of Illinois." Physics Teacher 3,2:82.

Tacoma Public Schools. "The Method of Scientists." SCOPE; June, 1962.

Thier, Herbert D., Karplus, Robert, and Powell, Cynthia Ann. "A Concept of Matter for First Grade." Journal of Research in Science Teaching 1:315; 1963.

Thompson, J. J. "New Method of Science Teaching." Science Education 48:390-392; October, 1964.

Tricker, R. A. R. "Impressions of the Teaching of Science in Schools in the United States of America." School Science and Mathematics; January, 1962.

Trowbridge, L. W. "Comparisons of Objectives and Instructional Materials in Two Types of High School Physics Courses." Science Education 49:117-122; March, 1965.

Usova, A. V. "Elementary Information on Physics in the Fourth Grade." Soviet Education 7:17-22; August, 1965.

Van Deventer, W. C. "BSCS Biology." School Science and Mathematics; February, 1963.

_____. "BSCS Materials in the Preparation of Teachers of Biology." School Science and Mathematics 64:683-693; November, 1964.

Voss, Burton E. "An Evaluation of the Chemistry Topics in the BSCS Blue Version." Journal of Research in Science Teaching 1:352; 1963.

Walbesser, H. H. "Science Curriculum Evaluation: Observations on a Position." Science Teacher 33:34-35+; February, 1966.

Walsh, George A., O.S.F.F. and Kelly, Patrick, O.S.F.F. "BSCS in the Yellow Version." Catholic School Journal; October, 1963.

Ward, Rita Rose. Evolution in the New Biology Texts. Firm Foundation; June 30, 1964.

Weisner, J. B. "Face-lift for the Science Curriculum." The UNESCO Courier 16:32-36; July, 1963.

Wong, Harry K. "Programming a High School Biology Course." The American Biology Teacher; March, 1964.

Wood, John K. "A Science Program for the Elementary Grades." Journal of Research in Science Teaching 3:323; 1964.

Ziegler, Robert. "Biological Sciences Curriculum Study." Illinois Science Newsletter; October, 1961.

VI INDEX

AAAS - 1, 3, 5, 11
Abilities - 6
Ability grouping - 6
Academic year institutes - 2, 6
Advanced topics - 19
Armchair investigation - 2
Astronomy - 1, 15, 16
Atkin, J. Myron - 16
Atomic model of matter - 18
Audiovisual aids - 4
Biology - 2, 11, 12, 20
Biology teacher's handbook - 11
Bisque, Ramon - 15
Bloom, B. - 3, 5
BSCS - 4, 5, 11, 12, 13
  Blue - 4, 11, 12, 13
  Green - 4, 11
  Yellow - 4, 11
  Other publications - 4, 5, 11, 12, 13
  Second course - 12
  Special materials - 4, 17
Blue Version - 4, 11, 12, 13
CBA - 13, 19
Cheldelin, Vernon - 19
CHEM - 14, 19
Chemical systems - 13
Chemistry - 2, 14, 20, 21
Chemistry and Experimental Science - 14
Clearinghouse report - 2
Commission on Engineering Education - 14
Computers - 14
Coordinated science and mathematics units - 18
Cultural physics - 17
Culturally disadvantaged - 15
Curriculum development - 2, 5
David, E. E. - 14
Director of Field Service - Extension Division - 7
Earth - 15
Earth science - 2, 3, 15, 20
Earth Science Curriculum Project - 1, 3, 15
ECCP - 14
Educational Services Incorporated - 18
Elementary school - 1, 3, 4, 11, 16, 17, 18, 20, 21
Elementary Science Project - 15
Elementary Science Study - 15
Energy control - 14
Engineering Concepts Curriculum Project - 3, 6, 14
ESP - 15
ESCP - 1, 15
ESI - 3, 19, 20
ESS - 3, 15
ESSP-California - 3, 15
ESSP-Illinois - 16
ESSP-Utah - 3, 17
Evaluation - 2, 3, 5, 11
Ferris, Frederick - 21
Films - 2, 4, 7, 11, 14
Geography - 21
Geology - 1, 15, 21
Geophysics - 15, 21
Green Version - 4, 11
Guides - 5
  Laboratory - 2, 4, 6, 11, 14
  Curriculum - 2, 5
  Teacher - 2
Haber-Schaim, Uri - 18, 19
Harvard Project Physics - 3, 17
Hawkins, David - 15
High ability - 6
Holton, Gerald - 19
HPP - 17
Hydrologic cycle - 15
Inquiry - 12
Inservice programs - 11
Inservice workshops - Institutes
  Academic year - 2, 6
  Summer - 2, 6
Intellectual schemes - 4
Integrated science - 19
Interdisciplinary - 21
Intermediate school - 3, 8, 11, 16, 18, 20
Introductory Physical Science - 18
IPS - 18
Invitations to inquiry - 6
Junior high school - 9, 15, 16, 18, 21
Karplus, Robert - 20
Kits - 4, 5, 11
Laboratory - 2, 14
Laboratory block - 6, 11
Laboratory equipment - 4, 7
Laboratory manuals - 4
Logic circuits - 14
Low ability - 6, 12
Man-made world - 14
Mason, Herbert - 16
Mathematics-Science - 18
Mayer, William - 11, 12, 13
Meteorology - 15
Minnemast - 3, 18
National Defense Education Act - 7
National Science Foundation - 2, 6
Oceanography - 15
Paige, Joe - 15
Pamphlets - 4, 11, 13
Particle nature of matter - 18
Patterns & Processes - 13
Physics - 17, 19, 20, 21
Physical Science Study Committee - 18, 19, 20
Pimentel, George - 14
Planetarium - 15
Portland Project - 19
Primary school - 1, 3, 4, 8, 11, 17, 18, 20

Princeton Project - 21
Processes of science - 1, 18
Products of science - 1
Programmed instruction - 4, 14
PSSC - 19, 20
Report of new curricula - 2
Rock cycle - 15
Salinger, Richard - 21
Sanders, N. - 3
Science - A Process Approach - 1, 3, 5, 11
Science Curriculum Improvement Study - 20
Science education - 7
Science units - 15
School Science Curriculum Study - 21
SCIS - 20
Second Course, BSCS - 12
Selection of curriculum materials - 2
Senior high school - 3, 10, 11, 12, 13, 14, 17, 19, 20, 21
Single concept films - See films
Slow learner - 6
Special materials - 4, 17
SSSP - 1, 21
State Department of Public Instruction - 7
State Science Supervisor - 7
State Universities - 7
Strong, Lawrence - 13
Student
  Text - 3
  Culturally disadvantaged - 15
  Low ability - 6, 12
  High ability - 6
  Evaluation - 2, 3, 5, 11, 13, 14
Summer institutes - 2, 6
Supplementary readings - 4, 11, 13
Taxonomy of Educational Objectives - 3
Teacher - 2
Teacher aids - 5
Teacher guides - 2, 3
Teacher preparation - 6
Technique films - See films
Tests - 2, 5, 11, 13, 14
Themes - 4, 11
Time-Space-Matter - 1, 21
Title III - NDEA - 7
Unified science - 19
Units - 4
University of Wisconsin-Madison - 7
University of Wisconsin-Milwaukee - 7
Werntz, James - 18
Wood, John - 17
Workshops - 5, 7
Yellow Version - 4, 11
Zacharias, Gerald - 20